Comments on "Nonlinear Elastic Response in Solid Helium: Critical Velocity or Strain?"

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Abstract

We make comments on Day *et al.*'s [*Phys. Rev. Lett.* 104, 075302 (2010)] paper. Our focus is upon the hysteresis loop in Figure 3 of this paper which was not closed.

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Day *et al.* recently measured the shear modulus over a wide frequency range and they then found out, in contrast with the torsional oscillator behavior, the elastic shear modulus depends on the magnitude of stress, but not velocity [1]. In [1] they showed the hysteresis in the shear modulus (cf. Fig. 3 [1]). In fact as reported in [1] hysteresis appears when the sample is cooled below 60 mK and is nearly temperature independent below 45 mK. Day *et al.* interpreted their (hysteresis) results in terms of the motion of dislocations which are weakly pinned by ^{3}He impurities but which break away when large stresses are applied.
The present author has other different explanation than above or [1] and relevant remarks especially about the nearly closing of the hysteresis loop in Fig. 3 [1]. Firstly, after re-arranging the data in [1] ($\sigma = \mu\epsilon$, cf. Fig. 4 for 2000Hz curve [1]), we can understand there are plastic flows [2-3] during the experiments. This can be evidenced in Fig. 1 as the shear stress-strain curve is not linear around $\epsilon \geq 0.3 \times 10^{-6}$ (yielding occurs). Meanwhile although the (shear) stress-strain data is isothermal but as the hysteresis loop in Fig. 3 of [1] is not closed thus there are adiabatic (shear) stress-strain regime in Fig. 3 of [1]. The latter can be rearranged and illustrated in Fig. 2. The crucial note is the adiabatic increase of temperature triggers the thermal softening phenomenon and reduces the rate of strain hardening (the shear modulus or (flow) stress can be reduced 17% as shown in Fig. 1 of [1]). To be concise when the outer layer of solid ^{4}He is subjected to plastic distortion most of the work done reappears in the form of heat, but a certain proportion remains latent and is associated with the changes to which plastic distortion give rise in the physical properties of the solid ^{4}He. When the solid ^{4}He is heated all the latent heat must be released before the melting point is reached, and when it is dissolved the latent heat must appear as a heat of solution. It seems to the present author that the identifying of the adiabatic regime is essential to the possible observation of superfluidity of solid ^{4}He in [1].

[1] J. Day, O. Syshchenko and J. Beamish, Phys. Rev. Lett. **104**, 075302 (2010).

[2] P.-G. de Gennes, C. R. Physique **7**, 561 (2006). C. Josserand, Y. Pomeau and S. Rica, Phys. Rev. Lett. **98**, 195301 (2007).

[3] Z.K.-H. Chu, Ann. Phys. (Berlin) **17**, 343 (2008).

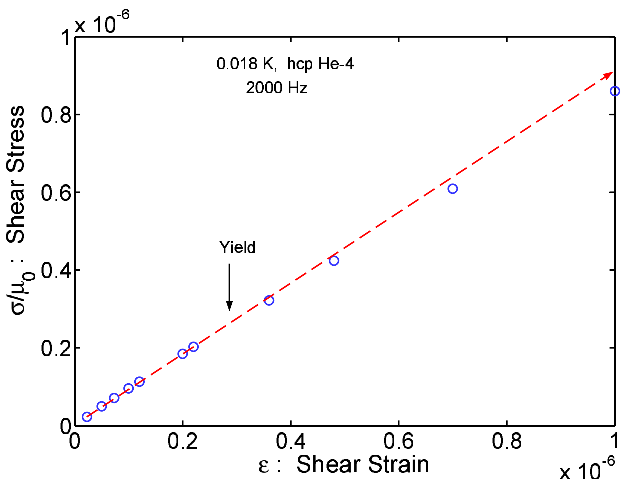

FIG. 1. Possible plastic flow in Day *et al.*'s measurements (cf. Fig. 4 in [1]). The onset of yielding relates to the departure from the linear relation (shear stress vs. strain).

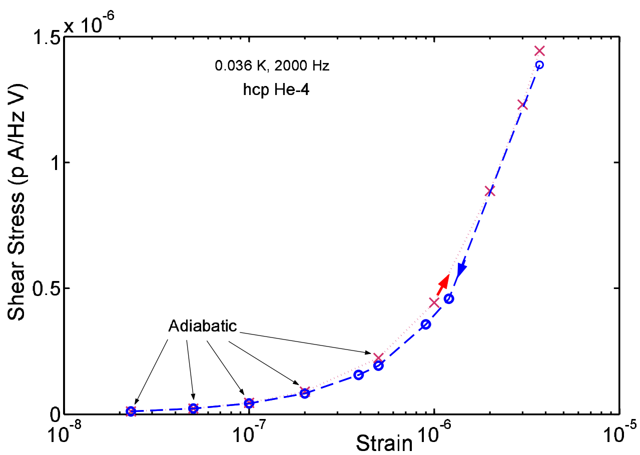

FIG. 2. Possible adiabatic (shear) stress-strain regime in Day *et al.*'s measurements (cf. Fig. 3 in [1]). In fact the hysteresis loop is not closed in the isothermal stress-strain data (cf. Fig. 3 in [1]). Arrows follow those in Fig. 3 of [1].